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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte STEFANIE R. CHIRAS,
MICHAEL W. LANE, ROBERT ROSENBERG,
and TERRY A. SPOONER

Appeal 2008-5925
Application 10/722,558
Technology Center 2800

Decided: January 27, 2009

Before EDWARD C. KIMLIN, ADRIENE LEPIANE HANLON, and
TERRY J. OWENS, *Administrative Patent Judges*.

OWENS, *Administrative Patent Judge*.

DECISION ON APPEAL
STATEMENT OF THE CASE

The Appellants appeal under 35 U.S.C. § 134(a) from the Examiner's rejection of claims 1, 3-15, 17-22, 31 and 32, which are all of the pending claims. We have jurisdiction under 35 U.S.C. § 6(b).

The Invention

The Appellants claim a process for forming an electrically conductive metallic interconnect in a via in a low-k dielectric having a dielectric constant of less than 3.9. Claim 1 is illustrative:

1. A process for forming an electrically conductive metallic interconnect in an via in a dielectric which comprises:

providing a dielectric layer in^[1] a substrate wherein the substrate comprises electrically conductive lines, wherein the dielectric layer comprises a low-k dielectric having a dielectric constant of less than 3.9,

forming a trench or via in the dielectric layer and exposing electrically conductive line in the substrate;

depositing a first liner layer on the walls and bottom of the trench or via;

removing residual contamination from the bottom of the trench or via;

depositing a second liner layer on the walls and bottom of the trench or via;

depositing a seed layer in the trench or via and

filling the trench or via with electrically conductive material.

The References

Cole	5,897,368	Apr. 27, 1999
Uzoh	6,140,234	Oct. 31, 2000
Schmidbauer	6,221,757 B1	Apr. 24, 2001
Lee	6,486,059 B2	Nov. 26, 2002
Lu	EP 1 233 448 A3	Aug. 21, 2002

¹ It appears that “in” should be “on” (see Spec. 3:4; Fig. 8).

The Rejections

The claims stand rejected under 35 U.S.C. § 103 as follows: claims 1 and 3-14 over Lu in view of Lee; claims 15 and 17-22 over Lu in view of Lee and Cole; and claims 31 and 32 over Lu in view of Lee and either Uzoh or Schmidbauer.

OPINION

The rejections are affirmed as to claims 1, 3-14, 31 and 32, and reversed as to claims 15 and 17-22. Under 37 C.F.R. § 41.50(b) a new ground of rejection of claims 15 and 17-22 is entered.

Rejection of claims 1 and 3-14 over Lu in view of Lee

The Appellants argue claims 1 and 3-14 as a group (Br. 5-9). We therefore limit our discussion to one claim in that group, i.e., claim 1. *See* 37 C.F.R. § 41.37(c)(1)(vii) (2007).

Issue

Have the Appellants shown reversible error in the Examiner's determination that the applied references would have rendered *prima facie* obvious, to one of ordinary skill in the art, carrying out the Appellants' claimed process using a low-k dielectric layer having a dielectric constant of less than 3.9?

Findings of Fact

Lu discloses a process for making a two layer barrier/liner for a via or contact (col. 1, ll. 57-58). Lu deposits a thin barrier/liner (124) within a via or contact in an interlevel dielectric (ILD 102), sputter etches to remove the barrier/liner at the bottom of the via/contact and clean the via/contact bottom, deposits a second barrier/liner (126) on the sidewalls and bottom of

the via/contact, deposits a copper seed layer over the second barrier/liner layer, and uses electrochemical deposition to fill the via/contact with copper (col. 1, l. 57 – col. 2, l. 5; col. 2, ll. 49-51; col. 3, ll. 6-9; col. 3, l. 58 – col. 4, l. 6; col. 4, ll. 38-42). Lu’s exemplified dielectrics are silicon dioxides, fluorine-doped silicate glass, organo-silicate glass, hydrogen silesquioxane, and combinations thereof (col. 3, ll. 35-39).²

Lee discloses “a via hole exposing a predetermined region of a metal wire and surrounded by a first low-k dielectric layer, and a trench over the via hole surrounded by a second low-k dielectric layer” (col. 2, ll. 22-25). The disclosed low-k materials include spin-on polymers and materials known under the trade designations SILK, Coral, Aurora and Black Diamond (col. 2, ll. 25-32), which are among the Appellants’ low-k materials (Spec. 4).

Analysis

The Appellants argue (Br. 5):

As discussed in the specification [(p. 1)], the present invention relates to reducing field induced metal contamination of the dielectric and/or leakage failure of the metallic interconnect and is of especial significance when the dielectric is a low-k dielectric. On the other hand, Lu et al. are concerned with eliminating overhang in

² Hydrogen silesquioxane is a low-k dielectric having a dielectric constant of about 3.0 or 3.1. See “Philips Develops Silicon BiCMOS Process”, *Semiconductor Int'l*, <http://www.semiconductor.net/article/CA163884.html> (“Hydrogen silesquioxane (HSQ), which has a low dielectric constant of 3.0”); Sung-Hyung Park et al., “Dependence of Plasma Process Induced Damage on the Transistor Gate Area”, *2001 6th Int'l Symp. on Plasma Process-Induced Damage, May 14-15, Monterey, CA, USA* 125 (American Vacuum Society, 2001) (“Two kinds of low-k IMD materials, HSQ (Hydrogen silesquioxane) and HDP FSG (Fluorinated Silicate Glass) with a dielectric constant of 3.1 and 3.7, respectively”).

liner/barrier/seed deposition and not with the problems addressed by the present invention which are especially pronounced when the dielectric is a low-k dielectric as recited in the present claims. Although, Lee et al. discloses low[-]k dielectric, no motivation exists in Lee at [sic] al. or Lu et al. to suggest that the problems of reduced field induced metal contamination of low[-]k dielectric would or could be achieved if a low[-]k dielectric were employed in the process [of] Lu et al.

As stated by the Supreme Court in *KSR Int'l. Co. v. Teleflex Inc.*, 127 S. Ct. 1727, 1742 (2007), “[T]he problem motivating the patentee [Lu or Lee] may be only one of many addressed by the patent’s subject matter. The question is not whether the combination was obvious to the patentee but whether the combination was obvious to a person with ordinary skill in the art”. Hence, for the Appellants’ claimed process to have been *prima facie* obvious to one of ordinary skill in the art, it is not necessary that Lu or Lee addresses the problem addressed by the Appellants.

Regardless, Lee teaches that “[o]ne drawback of using copper is that copper diffuses/drifts easily into adjoining low-k ILD, and it causes damage to neighboring devices on the semiconductor substrate” (col. 1, ll. 27-29). Thus, Lee points out the problem of metal contamination of a low-k dielectric addressed by the Appellants.

One of ordinary skill in the art, through no more than ordinary creativity, would have realized that the problem of metal contamination resulting from copper diffusion into a low-k dielectric would be prevented by Lu’s second barrier/liner 126 because it covers the bottom as well as the sidewalls of the via/contact (col. 3, ll. 6-9). *See KSR*, 127 S. Ct. at 1741 (In making an obviousness determination one “can take account of the inferences and creative steps that a person of ordinary skill in the art would

employ"). Consequently, one of ordinary skill in the art would have considered Lee's low-k ILD to be a suitable ILD in Lu's process in addition to the ILDs exemplified by Lu (col. 3, ll. 35-39).

Moreover, as pointed out above, Lu's dielectrics include hydrogen silesquioxane, which has a dielectric constant of about 3.0 to 3.1. Hence, Lu itself discloses each step in the Appellants' claim 1.

Conclusion of Law

The Appellants have not shown reversible error in the Examiner's determination that the applied references would have rendered *prima facie* obvious, to one of ordinary skill in the art, carrying out the Appellants' claimed process using a low-k dielectric layer having a dielectric constant of less than 3.9.

*Rejection of claims 15 and 17-22
over Lu in view of Lee and Cole*

Issue

Have the Appellants shown reversible error in the Examiner's determination that the applied references would have rendered *prima facie* obvious, to one of ordinary skill in the art, depositing an adhesion liner layer prior to depositing the first liner layer and wherein residual contamination and the adhesion liner layer are removed from the bottom of the trench or via prior to depositing the first liner layer?

Findings of Fact

Cole discloses "interconnect metallization overlying a polymer layer and extending through vias in the polymer layer to underlying contact metallization" (col. 1, ll. 5-7). Cole applies a tin chloride or palladium chloride first seed layer (22) over via sidewalls (21) and horizontal dielectric

material (14) and contact metallization (12) surfaces (col. 3, ll. 49-53). The first seed layer is back sputtered off the horizontal surfaces of the contact metallization, i.e., the bottom surfaces of the vias, and the horizontal surface (23) of the dielectric material, leaving a sufficient portion of the first seed layer on the via sidewalls to act as a catalyst for depositing a second seed layer on the sidewalls (col. 4, ll. 13-21). The second seed layer comprises a thin layer of sputtered titanium coated by a thin layer of sputtered copper (col. 4, ll. 24-27). A portion (24) of the second seed layer adheres to the horizontal dielectric material, and portions (26) adhere to the contact metallization, but regions on the via sidewalls receive little or no additional metal coverage (col. 4, ll. 27-31). Immersion in an electroless solution of copper or nickel results in reaction with the first seed layer that replaces it with a third seed layer that also can be plated on the second seed layer (col. 4, ll. 56-67). An electroplated copper layer then is formed on the second and third seed layers (col. 5, ll. 1-7). Cole teaches that the two step process of forming the first seed layer on the vertical surfaces and forming the second seed layer on the horizontal dielectric material and contact metallization surfaces achieves optimum adhesion to both the sidewalls and the horizontal surfaces (col. 4, ll. 32-50).

Analysis

The Examiner argues (Ans. 5):

Cole, Jr. et al. discloses forming an adhesion layer 22 in a via and removing the adhesion layer from the bottom of the trench prior to depositing additional metallization layers (see figs. 2-4 and col. 3-line 49 to col. 4-line 31). In view of these disclosures, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the device of Lu et al. so as to form an

adhesion layer on the inner vertical surfaces of the via because this will allow for optimum adhesion of subsequently deposited layers.

The Appellants argue (Br. 9-10):

Cole, Jr. does not disclose an adhesion layer as asserted by the examiner. Instead, layer 22 is a seed layer with [sic] is used to achieve subsequent deposition from an electroless plating bath. The barrier layers of Lu are not to be deposited by electroless plating but instead by PVD [physical vapor deposition] or CVD [chemical vapor deposition]. Only after depositing the barrier layers in Lu, is there mention of a seed layer like in Cole, Jr. along with subsequent electroless plating.

The Examiner responds that “the examiner respectfully disagrees since Cole, Jr. et al. discloses that having two layers provides optimum adhesion (see col. 4-lines 33-35), and this provides ample motivation for adding a second adhesion layer to the primary reference of Lu et al.” (Ans. 8).

Cole’s tin chloride or palladium chloride first seed layer 22 (col. 3, ll. 52-53), which the Examiner relies upon as corresponding to the Appellants’ adhesion liner layer, does not have applied to it a barrier/liner layer of the type disclosed by Lu (col. 2, ll. 44-45). Lu’s first barrier/liner layer is a material such as an amorphous ternary transition metal-silicon nitride or a dielectric such as SiN (col. 2, ll. 55-58), whereas the material applied to Cole’s first seed layer is an electroless solution of copper or nickel which chemically reacts with the first seed layer to form a third seed layer (col. 4, ll. 58-62). Moreover, Cole’s optimum adhesion does not refer to the adhesion of a layer to the first seed layer. Instead, it refers to the optimum adhesion of the second seed layer to the contact metallization and the

horizontal dielectric material obtained by removing any oxide layer formed on the contact metallization and removing the loosely held first seed layer from the relatively smooth surface of the horizontal dielectric material which does not have the natural roughness of the via sidewalls (col. 4, ll. 33-50).

The Examiner does not address those differences between the processes of Lu and Cole and explain why, regardless of those differences, applying an adhesion liner layer before Lu's first barrier/liner would have been *prima facie* obvious to one of ordinary skill in the art.

Conclusion of Law

The Appellants have shown reversible error in the Examiner's determination that the applied references would have rendered *prima facie* obvious, to one of ordinary skill in the art, depositing an adhesion liner layer prior to depositing the first liner layer, and wherein residual contamination and an adhesion liner layer are removed from the bottom of the trench or via prior to depositing the first liner layer.

Rejection of claims 31 and 32 over Lu in view of Lee and Uzoh or Schmidbauer

The Appellants do not provide a substantive argument as to the separate patentability of claims 31 and 32 but, rather, rely upon the argument set forth with respect to claim 1 from which those claims indirectly depend (Br. 10). As discussed above regarding the rejection of claim 1, that argument does not convince us of reversible error in the Examiner's rejection.

New ground of rejection of claims 15 and 17-22

Under 37 C.F.R. § 41.50(b) we enter the following rejection of claims 15 and 17-22.

Claims 15 and 17-22 are rejected under 35 U.S.C. § 103 over Lu in view of the Appellants' admitted prior art.

Regarding claim 15, Lu, summarized above, discloses each step in the Appellants' claim 15 except depositing an adhesion liner prior to depositing the first barrier/liner, and removing residual contamination and the adhesion liner from the bottom of the trench or via prior to depositing the first liner layer.

However, the Appellants acknowledge that it was known in the art to deposit an adhesive liner layer such as TaN in a via/trench, etch away the TaN from the bottom of the via/trench to form a clean contact, and then deposit a barrier layer such as tantalum (Spec. 2). The Appellants state that etching away the TaN from the bottom of the via/trench tended to pattern into the dielectric such that when the tantalum barrier layer was deposited and sputter etched, the bottom of the via/trench was poorly covered, enabling subsequently deposited copper to escape through the defected liner into the dielectric, causing failure. *See id.*

One of ordinary skill in the art, through no more than ordinary creativity, would have recognized that the poor coverage of the bottom of the via/trench by the prior art tantalum barrier layer would not be a problem in Lu's process because the escape of the subsequently deposited copper into the dielectric would be prevented by Lu's second/barrier liner 126 which covers the bottom as well as the sidewalls of the via/contact (col. 3, ll. 6-9). *See KSR*, 127 S. Ct. at 1741. Hence, in view of Lu's disclosure that the first barrier/liner 124 should have good adhesion (col. 2, ll. 49-54), one of ordinary skill in the art would have been led, through no more than ordinary creativity, to deposit the prior art TaN adhesive liner layer prior to Lu's first

barrier/liner 124 to provide better adhesion of that barrier/liner. For a *prima facie* case of obviousness to be established, all that is required is a reasonable expectation, not absolute certainty, that the prior art TaN adhesive liner layer would improve the adhesion of Lu's first barrier/liner 124. *See In re O'Farrell*, 853 F.2d 894, 903-04 (Fed. Cir. 1988) ("Obviousness does not require absolute predictability of success. . . . For obviousness under § 103, all that is required is a reasonable expectation of success").

As for claims 17-22, the admitted prior art adhesion liner layer comprises a nitride of Ta as recited in claims 17 and 18,³ and Lu discloses the first liner layer comprising Ta recited in claims 19 and 21 (col. 2, ll. 49-56) and the second liner layer comprising Ta recited in claims 20 and 22 (col. 3, ll. 10-14).⁴

Accordingly, claims 15 and 17-22 are rejected under 35 U.S.C. § 103 over Lu in view of the Appellants' admitted prior art.

DECISION/ORDER

The rejections under 35 U.S.C. § 103 of claims 1 and 3-14 over Lu in view of Lee, and claims 31 and 32 over Lu in view of Lee and either Uzoh or Schmidbauer are affirmed. The rejection under 35 U.S.C. § 103 of claims 15 and 17-22 over Lu in view of Lee and Cole is reversed. Under 35 U.S.C. § 41.50(b), a new rejection is entered of claims 15 and 17-22.

It is ordered that the Examiner's decision is affirmed-in-part.

³ Claim 18 improperly depends from canceled claim 16.

⁴ Claim 22 improperly depends from itself.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a).

Regarding the affirmed rejection(s), 37 CFR § 41.52(a)(1) provides "[a]ppellant may file a single request for rehearing within two months from the date of the original decision of the Board."

In addition to affirming the examiner's rejection(s) of one or more claims, this decision contains a new ground of rejection pursuant to 37 CFR § 41.50(b) (effective September 13, 2004, 69 Fed. Reg. 49960 (August 12, 2004), 1286 Off. Gaz. Pat. Office 21 (September 7, 2004)). 37 CFR § 41.50(b) provides "[a] new ground of rejection pursuant to this paragraph shall not be considered final for judicial review."

37 CFR § 41.50(b) also provides that the appellant, WITHIN TWO MONTHS FROM THE DATE OF THE DECISION, must exercise one of the following two options with respect to the new ground of rejection to avoid termination of the appeal as to the rejected claims:

(1) Reopen prosecution. Submit an appropriate amendment of the claims so rejected or new evidence relating to the claims so rejected, or both, and have the matter reconsidered by the examiner, in which event the proceeding will be remanded to the examiner. . . .

(2) Request rehearing. Request that the proceeding be reheard under § 41.52 by the Board upon the same record. . . .

Should the appellant elect to prosecute further before the examiner pursuant to 37 CFR § 41.50(b)(1), in order to preserve the right to seek review under 35 U.S.C. §§ 141 or 145 with respect to the affirmed rejection, the effective date of the affirmance is deferred until conclusion of the

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prosecution before the examiner unless, as a mere incident to the limited prosecution, the affirmed rejection is overcome.

If the appellant elects prosecution before the examiner and this does not result in allowance of the application, abandonment or a second appeal, this case should be returned to the Board of Patent Appeals and Interferences for final action on the affirmed rejection, including any timely request for rehearing thereof.

AFFIRMED-IN-PART, 37 C.F.R. § 41.50(b)

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